

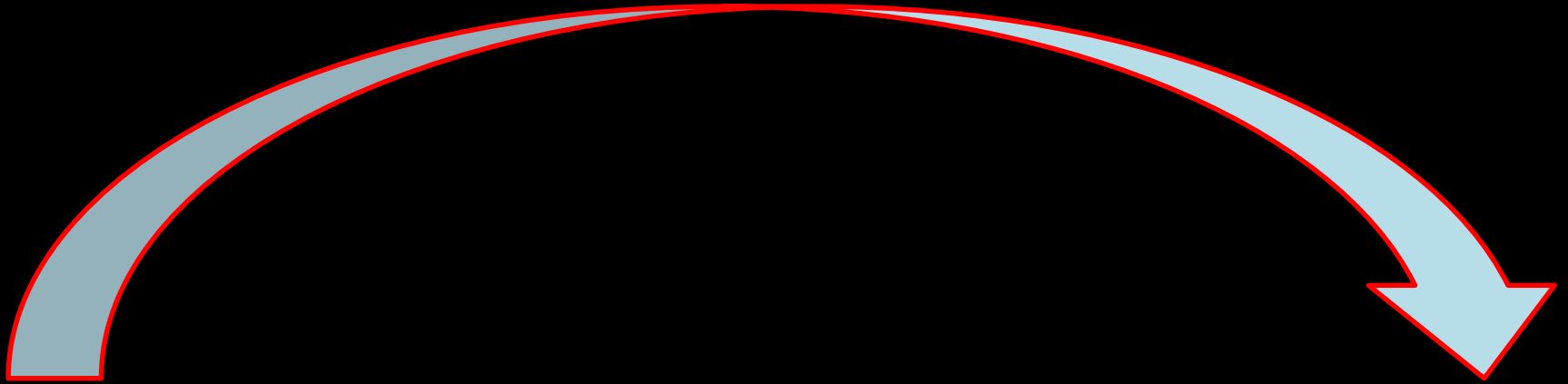
Trajectory of Storage Displacing and Replacing Conventional Generation

Michael Jacobs
October 2017

**[Union of
Concerned Scientists]**



Storage deployments displacing generation



2009 Reserves

Chile, Hawaii

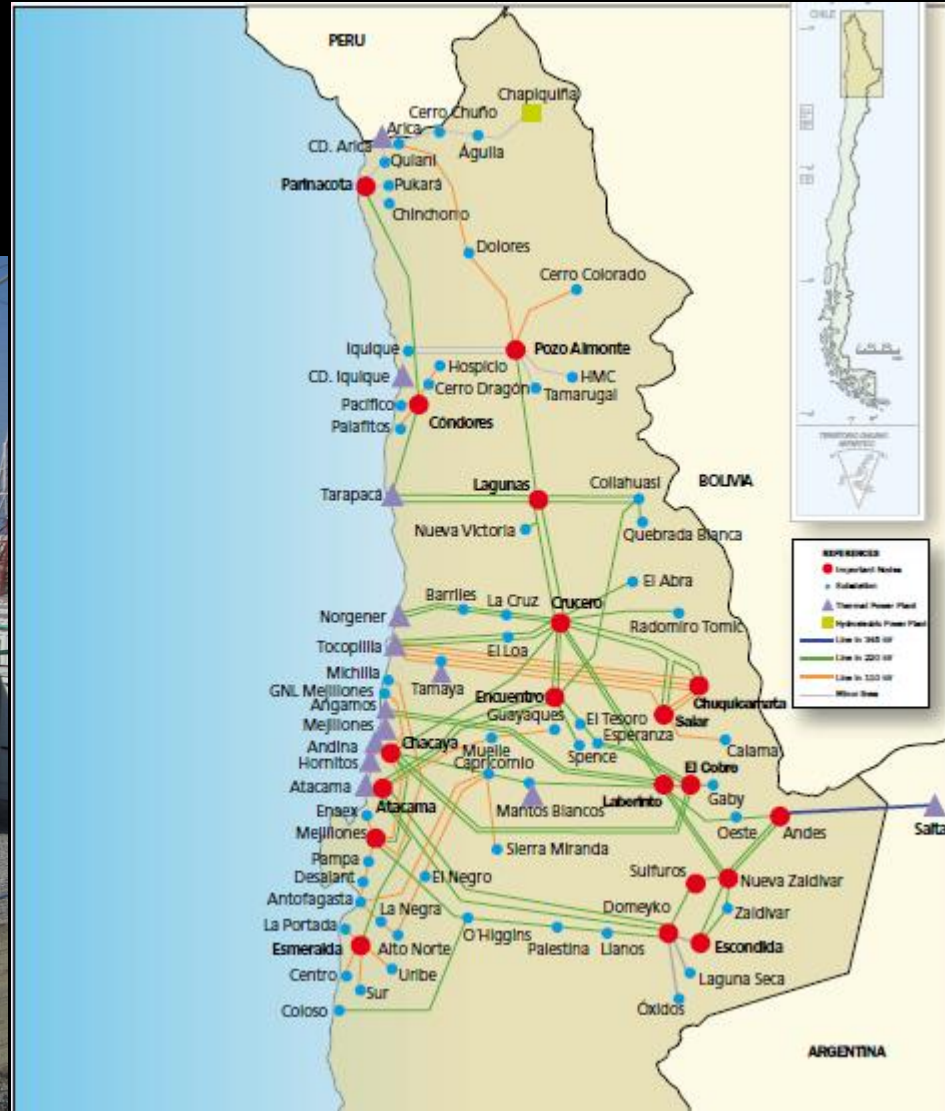
2012 Freq. Reg.

PJM, NY, NE

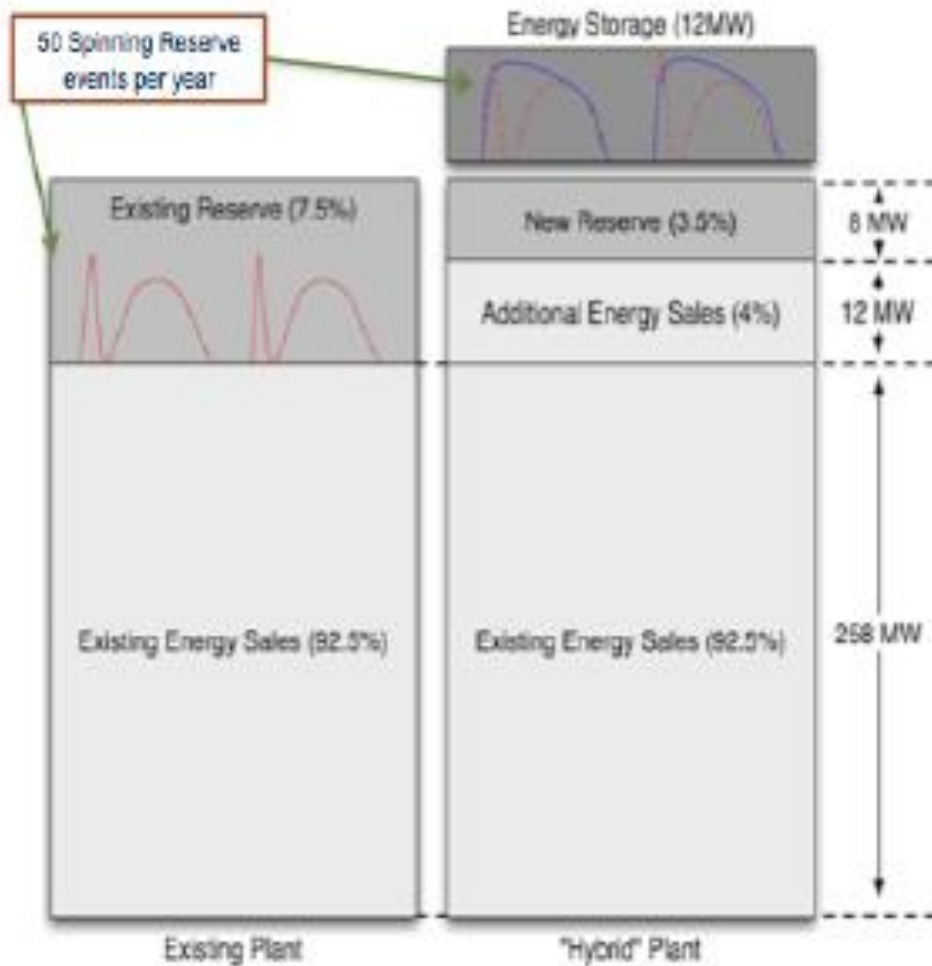
2016 Peak Plant

California

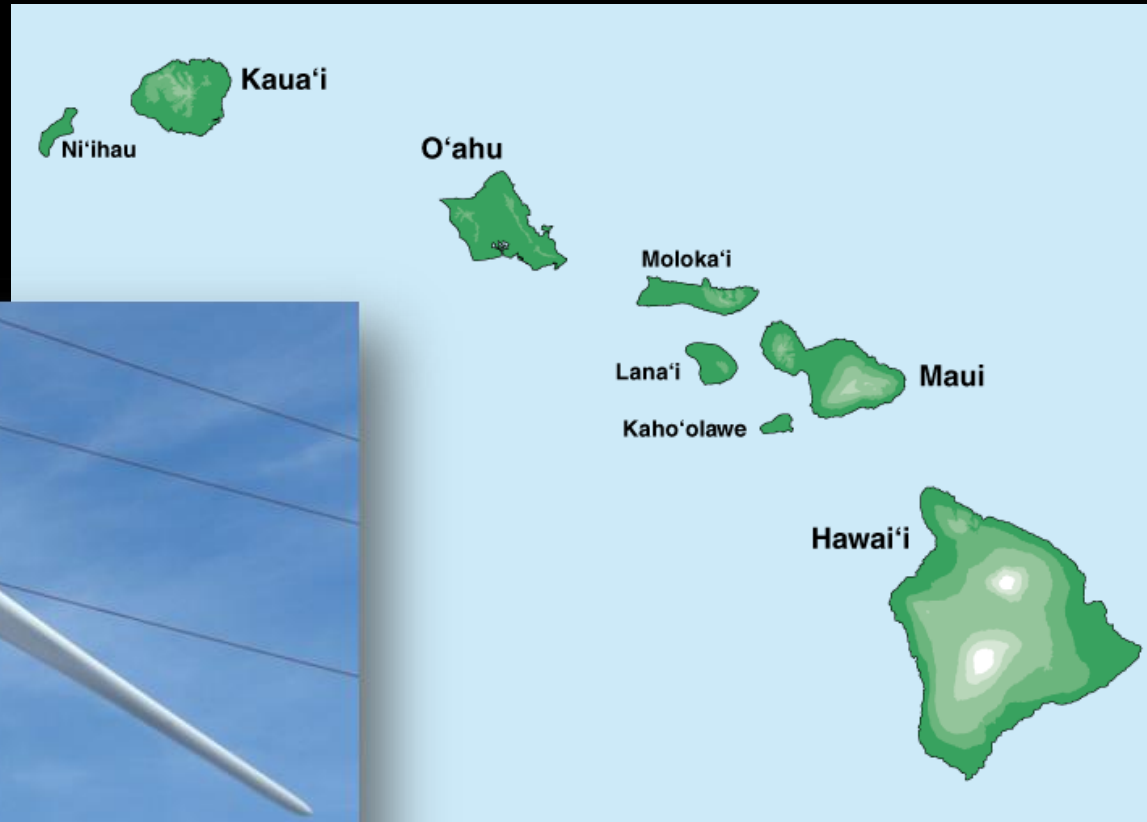
Chile 2009 - 2011



Chile Reserve in Storage

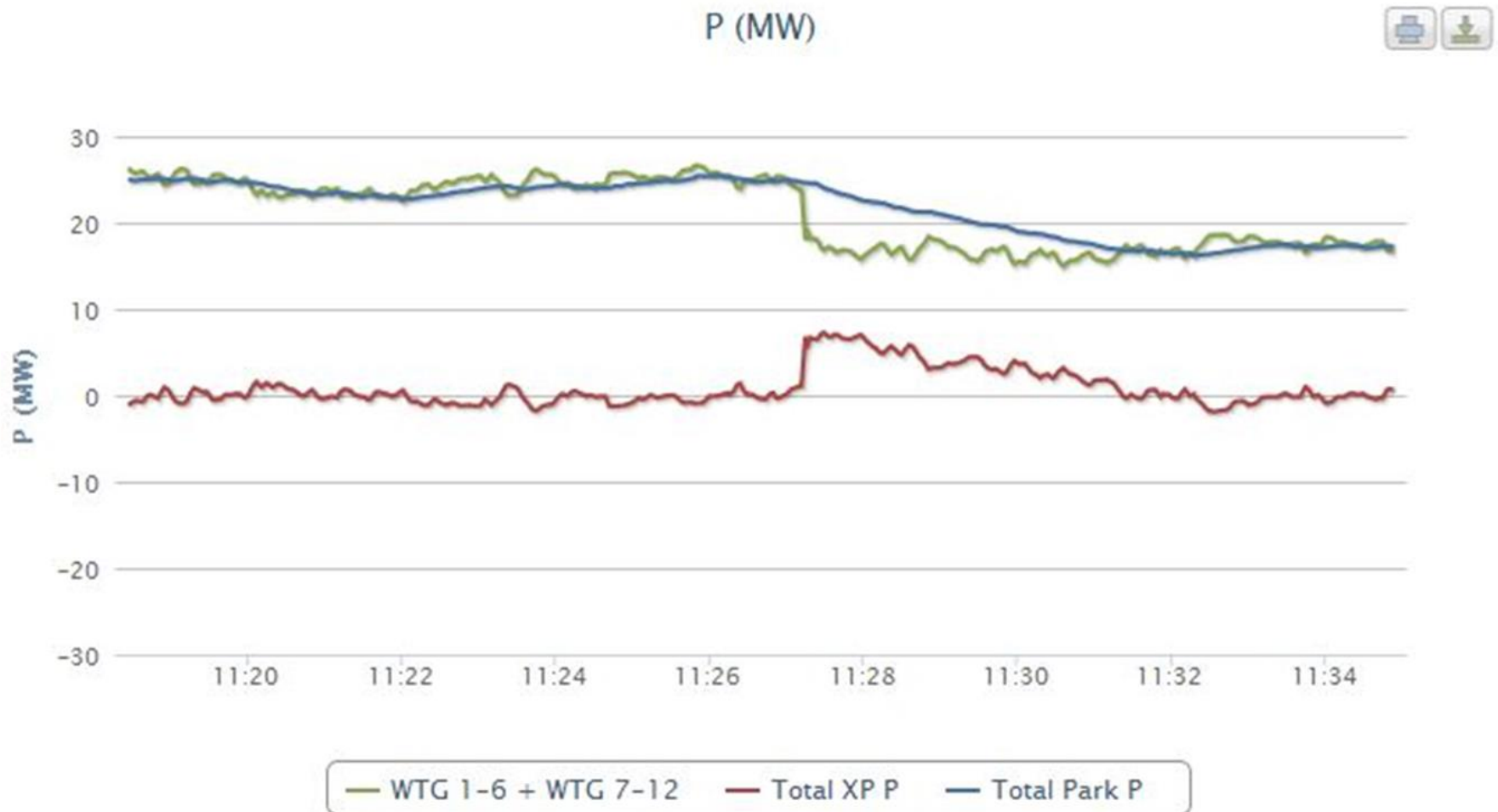


Hawaii 2009 - 2011

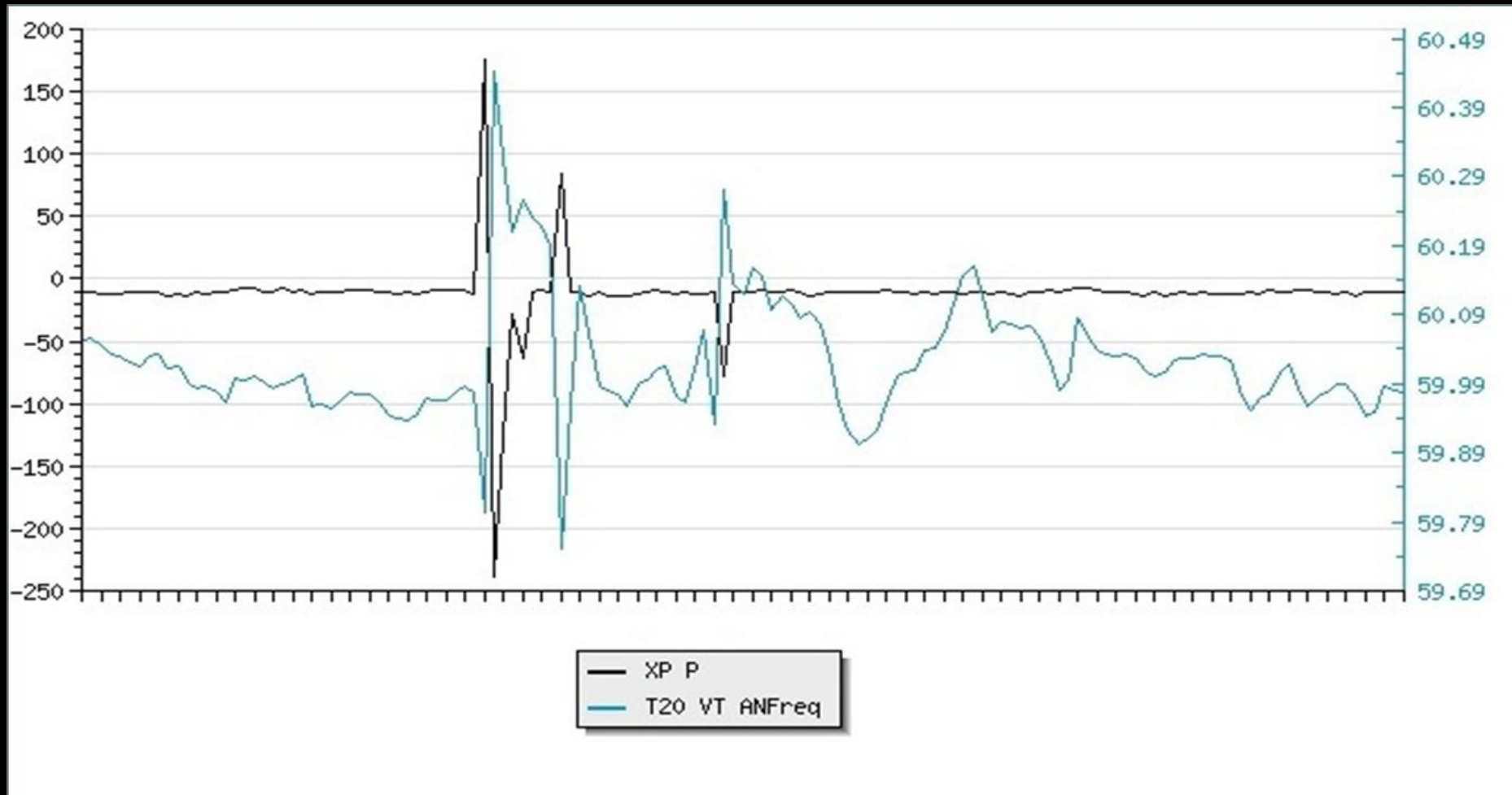


Smoothing in Hawaii

Xtreme Power's Kahuku Web Interface

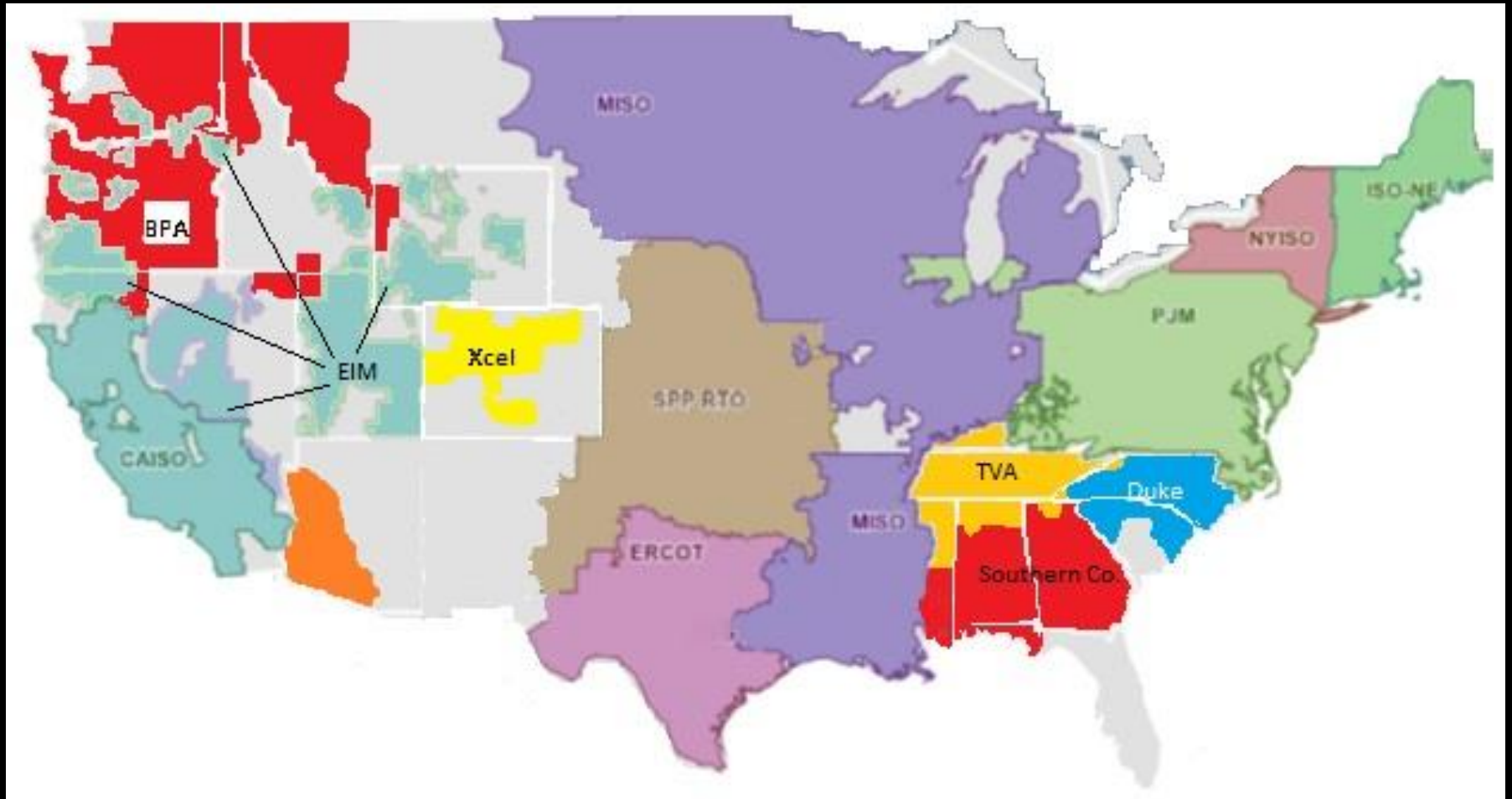


Hawaii Contingency Reserve



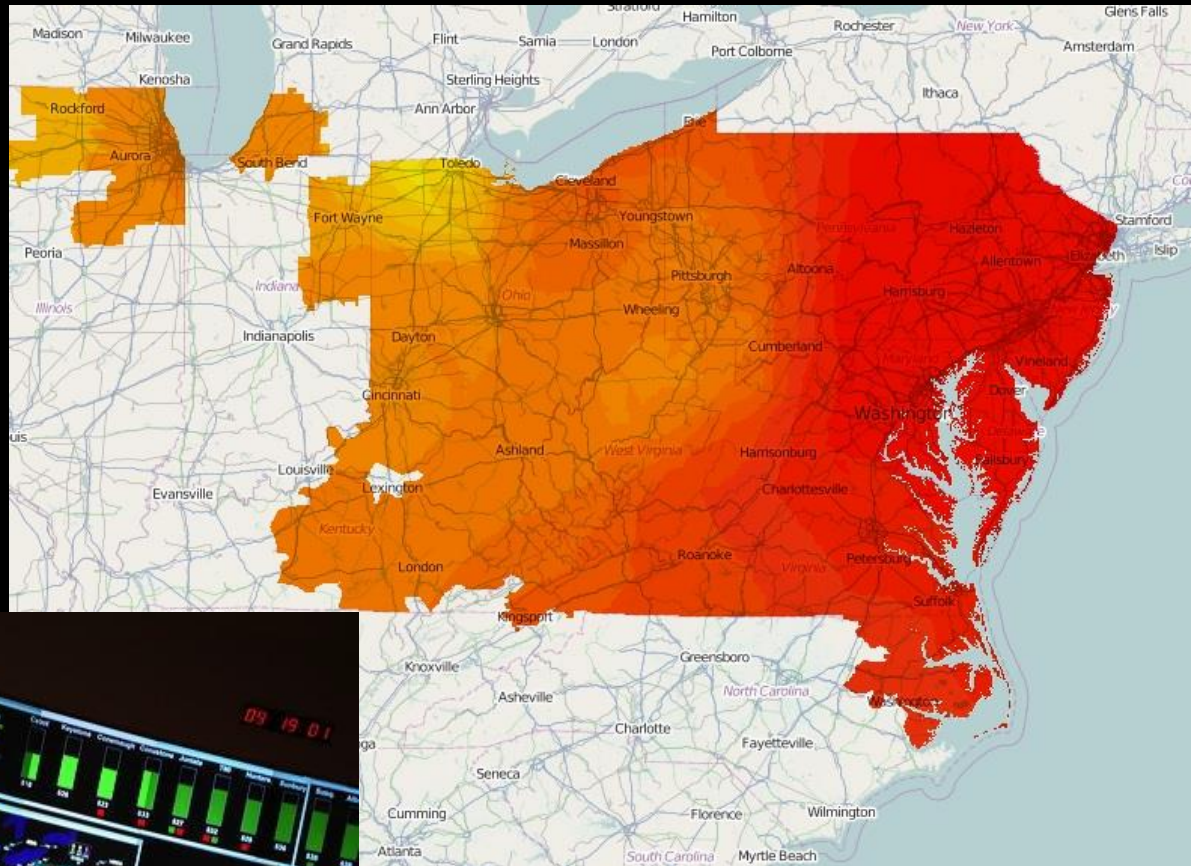
Battery responding to frequency disturbance

Power Pools Manage Variability

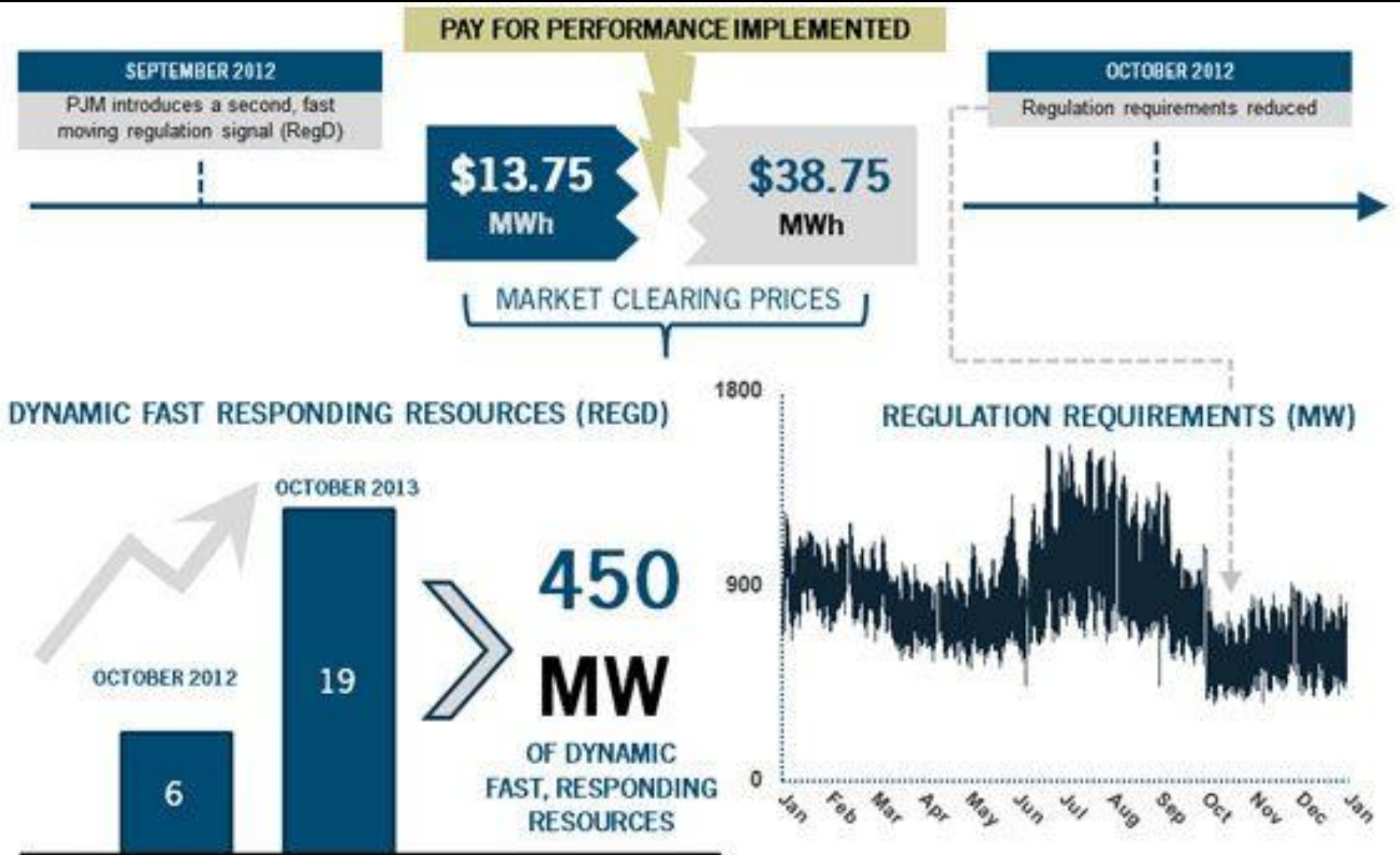


ISO-NE & PJM 2008 -2012

FERC Order 755 developed in 2010 from demonstrations including flywheels and batteries.



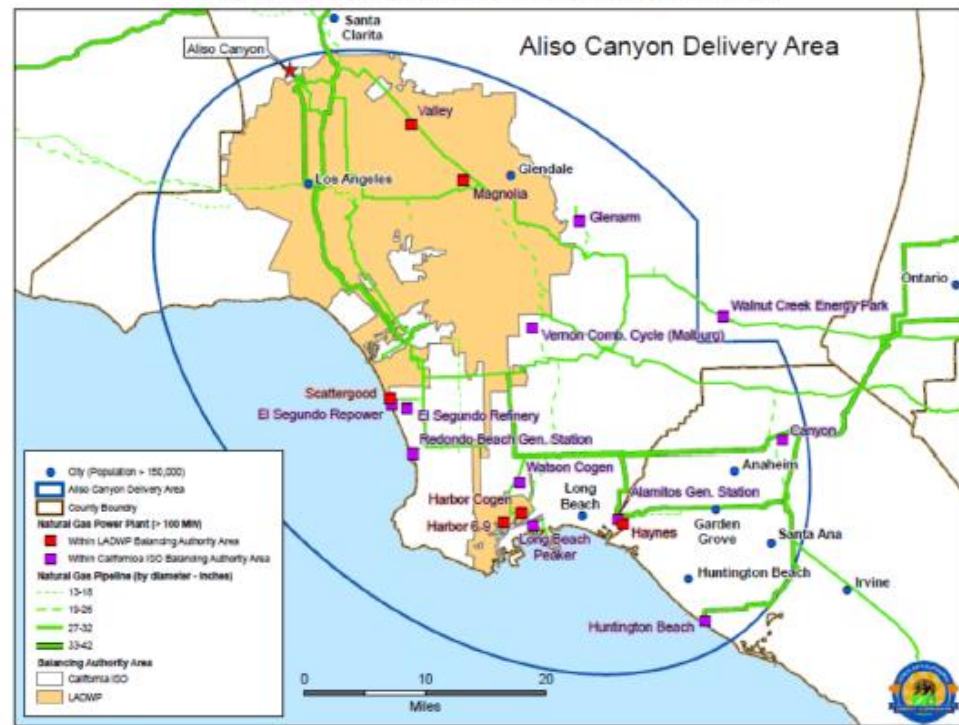
PJM Regulation Market



PJM coordinates frequency regulation through two different control signals:
RegD - fast moving dynamic regulation (e.g. batteries, flywheels)
RegA - Traditional regulation resources (e.g. single cycle gas turbines)

California 2016

Figure 2: Electric Generation Plants Served by Aliso Canyon

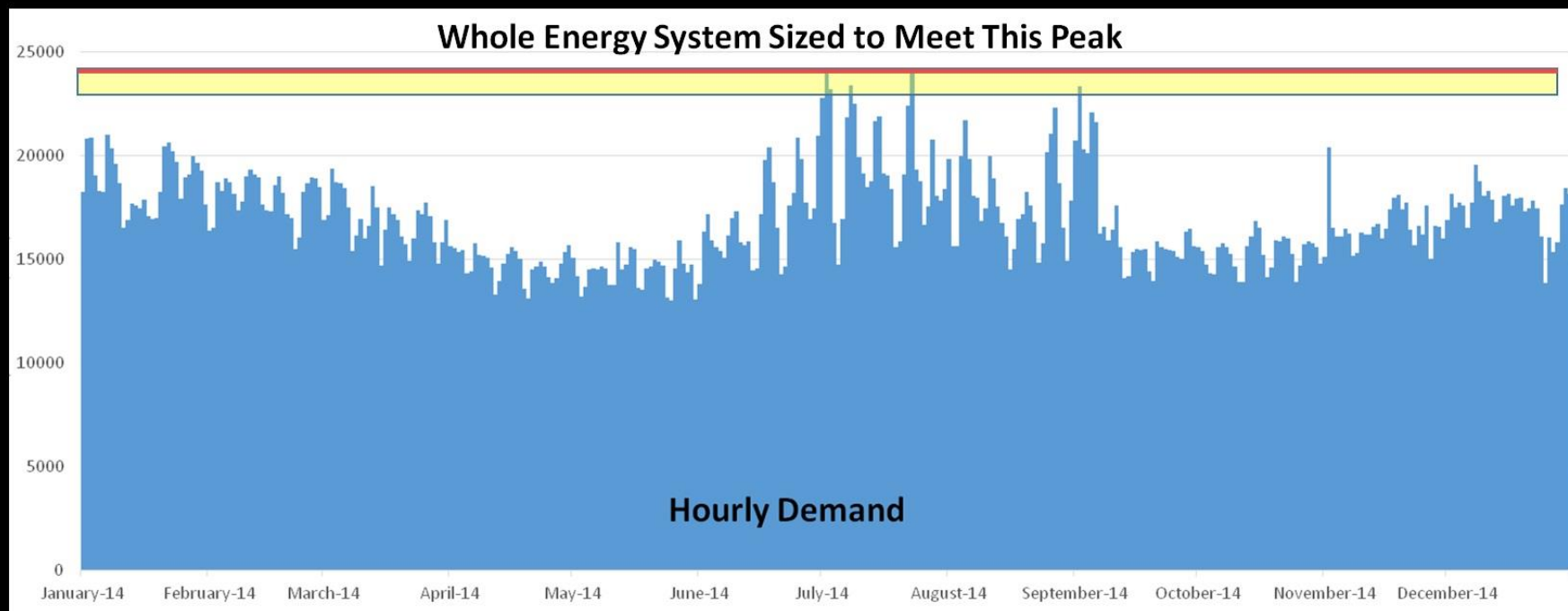


Source: Energy Commission Staff



CA Utility-procured & Operating

- AltaGas Pomona Energy 20 MW/80 MWH
- Western Grid Development 5 MW/20 MWH
- AES Escondido 30 MW/120 MWH
- AES El Cajon 7.5 MW/ 30 MWH
- Tesla Mira Loma 20 MW/ 80 MWH



2016 CAISO Inverter test at PV plant

Table 2. Measured regulation accuracy by 300 MW PV plant

Timeframe	Solar PV Plant Test Results
Sunrise	93.7%
Middle of the Day	87.1%
Sunset	87.4%

Table 3. Typical regulation up accuracy of CAISO conventional generation

	Combined Cycle	Gas Turbine	Hydro	Limited Energy Battery Resource	Pump Storage Turbine	Steam Turbine
Regulation-Up Accuracy	46.88%	63.08%	46.67%	61.35%	45.31%	40%

Replace 50 Year-old Coal

Consider: Waterfront coal - 689 MW

In-service since 1958 & 1962

Heat rate 10,600 Btu/kWh

Recent capacity factor ~30%



**[Union of
Concerned Scientists**

Future is Now

Renewable energy: abundant and cost-competitive
&
Storage: capable of all functions



Kauai solar and storage in 2011.

For more information, please contact

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<http://blog.ucsusa.org/mike-jacobs/how-do-we-get-to-100-percent-renewable-energy-the-role-of-storage>

<http://blog.ucsusa.org/mike-jacobs/what-would-we-do-with-cheap-energy-storage-batteries-722>

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